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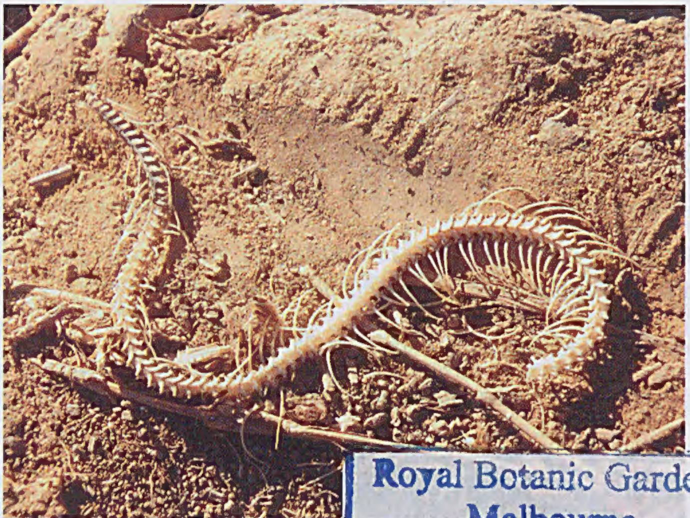

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Front cover: Skeletal remains of a snake. See page 174. Photo M Mo.
Back cover: Swamp Wallaby *Wallabia bicolor* caught by surveillance camera. See page 178

Research Report

Response to the Myrtle Rust incursion into Victoria, Australia, 2012

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Abstract
Myrtle Rust *Austropuccinia psidii* was first confirmed on nursery plants imported into Victoria from New South Wales on 4 January 2012. The state biosecurity agency initiated an emergency response and monitored the spread and host range of the disease in Victoria. The disease has been contained mostly to metropolitan Melbourne and is yet to be detected in natural ecosystems. Extensive communications with the media, councils and industry have raised awareness and interest in the progress of the disease and have assisted in identifying new detections and helped in limiting its spread. It is possible that Victorian weather patterns are not ideal for the fungus and have contained the spread of the disease. New hosts found in Victoria and not previously reported for Myrtle Rust were Rohutu *Lophomyrtus obcordata, Callistemon* 'Harkness' and *C. subulatus*. (*The Victorian Naturalist* **136** (5), 2019, 160–173)

Keywords: *Austropuccinia psidii, Puccinia psidii,* Myrtaceae, biosecurity response

Introduction

Rust of Myrtaceae, commonly known as Guava, O'hia, Eucalypt or Myrtle Rust, caused by *Austropuccinia psidii* (G. Winter) Beenken, formerly *Puccinia* (Beenken 2017), is a pathogen of many Myrtaceae species (https://www.plantwise.org/KnowledgeBank/datasheet/45846). *Austropuccinia psidii* was confirmed in Victoria, Australia, at a retail nursery on 4 January 2012 where symptoms were found on several genera of the Myrtaceae. This was approximately 20 months after its first detection in Australia on 21 April 2010 at the property of a cut flower grower on the New South Wales (NSW) central coast. On this property it was initially found on *Agonis flexuosa* 'After Dark' but subsequent surveys of the property detected it on *A. flexuosa* cv 'Burgundy', *Callistemon viminalis* and *Syncarpia glomulifera* (Carnegie *et al.* 2010). In December 2010 the first detection in Queensland was reported at a retail nursery in the south-east of the state where symptoms were found on *Gossia inophloia* (Pegg *et al.* 2014). By February 2015, it was found in Burnie, Tasmania, infecting *Lophomyrtus* spp. and Chilean Guava, *Ugni molinae* (http://biosecurityadvisory.dpipwe.tas.gov.au/). During May 2015, symptoms were found on *Eugenia reinwardtiana, Leptospermum madidum* and *Lithomyrtus retusa* on Melville Island off the coast of the Northern Territory (2016). More recently the fungus was reported on Lord Howe Island in October 2016 on *Syzygium jambos* (Holloway 2016) and on Norfolk Island in June 2017 on *S. jambos* (Queensland Plant Pathology Herbarium BRIP 66027).

The host range of *A. psidii* rapidly expanded after its first detection in Australia (Coutinho *et al.* 1998; Carnegie and Lidbetter 2012; Morin *et al.* 2012; Giblin and Carnegie 2014; Pegg *et al.* 2014). The current host range in Australia includes 57 genera (Giblin and Carnegie 2014). Several biotypes of the pathogen are known to exist. Glen *et al.* (2007) and Graça *et al.* (2013) suggested five major groups exist in Brazil. To date, evidence has been found for only one strain of *A. psidii* in Australia (Carnegie and

Lidbetter 2012; Sandhu and Park 2013; Machado *et al.* 2015).

Austropuccinia psidii is considered native to South and Central America and is now widely distributed in this region (Coutinho *et al.* 1998, Alfenas *et al.* 2005). The pathogen was first described on Common Guava *Psidium guajava* in Brazil by Winter in 1884 (Coutinho *et al.* 1998). Gonçalves (1929) reported *Uredo* sp. on a *Eucalyptus* sp. in Brazil. Re-examination of the herbarium specimens collected by Gonçalves, suggested the urediniospores were similar to the *Puccinia* (*A. psidii*) found on young plants of Lemon Scented Gum *Corymbia citriodora* in Brazil (Joffily 1944).

The pathogen was present on the Caribbean island of Jamaica in 1934, where it reportedly caused serious defoliation of Pimento *Pimenta dioica* (MacLachlan 1938). A severe epidemic on *Eucalyptus* in nurseries and young plantations was recorded in Brazil in 1973 (Ferreira 1983). Tree losses of up to 20% and canopy losses of up to 30% severely reduced growth rates and profits (Tommerup *et al.* 2003). Similarly, severe damage was reported on one-year-old *Eucalyptus* trees in Uruguay (Telechea *et al.* 2003). Indigenous *Eugenia* species in Hawaii were severely damaged by *A. psidii*, whilst widespread crown dieback was reported on the invasive Rose-apple *Syzygium jambos* (Uchida *et al.* 2006). Arrival of the fungus in Hawaii heightened the threat to Australian Myrtaceae (Glen *et al.* 2007). Interestingly, Rayachhetry *et al.* (2001) suggested the fungus as a potential biocontrol agent for the invasive weed Broad-leaved Paperbark *Melaleuca quinquenervia* in the south Florida environment. Recently *A. psidii* has been reported from Japan (Kawanishi *et al.* 2009), China (Zhuang and Wei 2011), South Africa (Roux *et al.* 2013), New Caledonia (Giblin 2013), Indonesia in 2015 (McTaggart *et al.* 2016), Indonesia in 2016 (du Plessis *et al.* (2017) and, most recently, on Raoul Island in the Kermadec Island Group of New Zealand (http://projectcrimson.org.nz/Myrtle_rust_alert/) and Kerikeri, North Island, New Zealand in 2017 (http://www.doc.govt.nz/news/media-releases/2017/Myrtle-rust-found-in-new-zealand/).

For some time, *A. psidii* was thought to have jumped hosts before 1912, from *P. guajava* to *C. citriodora*, but more recent work suggests it may have originated from an as yet unidentified Myrtaceae, rather than from Common Guava (Graça *et al.* 2013).

This paper reports the preparation for a Myrtle Rust incursion into Victoria and activities post the 2012 incursion, as monitored by the Biosecurity Branch of Agriculture Victoria, the Victorian State Government and its predecessor departments (referred to as Agriculture Victoria in this paper). The response following detection of the Myrtle Rust consisted of three phases. Phase 1 was the emergency response, where Infested Land Notices were issued and eradication activities were undertaken. The response moved to Phase 2, containment, when 20 infected premises (IPs) were identified. During Phase 2, advice on management was provided. Phase 3 commenced when 60 IPs were identified, and the disease was considered established in Victoria. The Department of Economic Development, Jobs, Transport and Resources (DEDJTR), of which Agriculture Victoria is a portfolio, continued to monitor potential spread into natural ecosystems and provided management options on request.

Activities reported herewith are governance, communications, surveillance, diagnostics, host range and management. Pre- and post-detection communication strategies were developed, and surveillance was directed towards early detection of infested locations (e.g. nurseries and sites of high visitor numbers) to inform asset protection management strategies, identify species at risk and alert stakeholders to the spread of the disease. Treatment options to contain the spread of Myrtle Rust were provided to the public and industry.

Governance

In May 2010, the Victorian Government responded to the detection of Myrtle Rust in NSW by prohibiting the movement of Myrtaceae plant material into Victoria from all states. All other non-affected states responded in a similar manner. In July 2010, movement of Myrtaceae plant material into Victoria from Queensland and NSW was allowed, but restricted to having come from a place 'free' of Myrtle Rust or having been certified as having been treated for Myrtle Rust by a government agency. In

June 2012, after the detection of Myrtle Rust in Victoria, Victoria was prohibited from sending Myrtaceae plant material to Western Australia and Tasmania, while South Australia and the Northern Territory required certification of site freedom from, and treatment for, Myrtle Rust. This certification later evolved into the Industry Certification Assurance 42 (ICA42).

Myrtle Rust coordination groups and Myrtle Rust Emergency Response Team

A Victorian Myrtle Rust Coordination Group was established in June 2011 in partnership with the Myrtle Rust National Coordination Group. Members of the group consisted of representatives from Department of Environment, Land, Water and Planning (DELWP), Nursery and Garden Industry of Victoria, Municipal Association of Victoria, Melbourne City Council, Vic Forests, Melbourne Water, Parks Victoria, catchment management authorities, Victorian Apiarists Association, indigenous plant revegetation and environmental groups (e.g. Landcare, Greening Australia), the Royal Botanic Gardens Victoria, Victorian Farmers Federation and Farm Forestry (Agriculture Victoria). This group enabled preparedness for spread of the disease and dissemination of information to raise awareness. It had a significant reach of stakeholders, including cut flower growers, professional arborists, gardeners, landscapers, gardening clubs, plant societies, farmers' markets, chemical resellers and the public, which facilitated forwarding of communications and information on Myrtle Rust. While the first suspected Myrtle Rust specimen was undergoing initial diagnosis, a Myrtle Rust Emergency Response Team under the management of the Victorian Chief Plant Health Officer was immediately set up to coordinate the incursion response and to liaise with the State and National Coordination Group.

Communications

The communication strategy for Victoria's Myrtle Rust response focused on awareness of the disease and its potential impact. It was agreed with the NSW Department of Primary Industries and Biosecurity Queensland that essentially the same information should be used by each agency, so consistent technical knowledge was disseminated.

The key messages for the public, the affected industries and the agencies during the pre-detection phase related to recognition and reporting of the disease, the potential impact of Myrtle Rust, confirmation of area freedom through ongoing surveillance and regulation of the movement of Myrtle Rust host material into Victoria with the required ICA 42 certification. Post-detection, Phase 2 messages included management strategies to minimise the impact and how reporting the disease would assist in its management and monitoring of its spread. Agriculture Victoria provided extensive training on Myrtle Rust throughout the response.

A contacts database was established to enable effective distribution of information for the life of the response program. Publications, factsheets, a CD-ROM, posters, information update sheets and industry notices were circulated through various channels, including email, the website and at information or industry training sessions, to stakeholders for distribution at events and through their organisational networks.

There were eight factsheets, two posters, seven information update sheets and 12 industry notices published. Additionally, 350 copies of version one and 150 copies of version two of the CD-ROM Myrtle Rust training resource were produced and distributed from August 2011 and September 2012, respectively. The content was based on one developed by Biosecurity Queensland but focused on host and disease recognition, locally infected host species and hygiene. The CD was distributed free of charge on request and to information session attendees. More than 5500 hard copies of factsheets were supplied for information to the general public and to industry.

To report suspected detections of Myrtle Rust, the public were encouraged to either email plant.protection@ecodev.vic.gov.au or telephone the Exotic Plant Pest Hotline (Freecall 1800 084 881). In Victoria, the Hotline was directed to the Agriculture Victoria Customer Service Centre (CSC), which was supplied with frequently asked questions (FAQs) and directions to enable reports to be logged with supporting information, so as many enquiries as possible could be handled without referrals to biosecurity officers. Over 451 suspect

detections were reported. The CSC was able to screen enquiries which would otherwise have been passed to biosecurity officers. This function of the CSC was very valuable.

Data on visits to the Myrtle Rust webpages showed a 13-fold increase in visits to the site following the first Victorian Myrtle Rust detection at the end of December 2011 (Table 1). It is believed the Agriculture Victoria media release of 6 January 2012, together with awareness generated through the Coordination Committee and 131 agencies (including 61 Victorian local governments, Regional Landcare Coordinators and other organisations) enabled rapid dissemination of information. A high level of interest was maintained until May 2012, then gradually declined. From January 2012 to January 2013 there was a 13-fold decrease in visits to the site. Patronage of the Myrtle Rust webpages linked to the homepage was varied; the most frequently and consistently visited of these pages were:
(i) What does Myrtle Rust look like? (659 visits in one month);
(ii) Which plants are affected? (381 visits); and
(iii) Treatment of Myrtle Rust in the home garden (211 visits).

Seventy-one information sessions were conducted in total, with over 3000 people attending. Information sessions typically ran for 1–2 hours and focused on the basics of Myrtle Rust and its detection and reporting; some sessions were organised by other agencies (e.g. local government, Landcare, and Nursery and Garden Industry of Victoria), with Agriculture Victoria presenting the content.

Industry notices regarding the movement of Myrtle Rust host materials were distributed during market access activities. The notices covered import and export restrictions for Victoria and other states/territories, as well as any required treatments of host materials.

A media release alerting Victorians to the threat of Myrtle Rust was issued in November 2011, before the first detection in Victoria, to encourage reporting and (hopefully) early detection of an incursion. Further releases were issued following the first detection on 28 December 2011 and there were more than 20 media items on Myrtle Rust in the five weeks following the first detection, with several outlets doing follow-up stories, particularly in affected areas. Additionally, there was a media release when import restrictions on host material were lifted in July 2012.

Table 1. Number of visits to website per month

Year	Month	Number of visits
2011	December	238
2012	January	3213
	February	3032
	March	1720
	April	1410
	May	1324
	June	541
	July	583
	August	517
	September	499
	October	628
	November	539
	December	262
2013	January	238
	February	324
	March	362
	April	321
	May	423
	June	264
Total		**16438**

Surveillance

Prior to detection in Victoria

Following the first detection of Myrtle Rust in NSW, the Victorian Government (Agriculture Victoria) instigated a pre-detection response of surveillance to maximise the chances of early detection through monitoring of high-risk areas or pathways (e.g. sites of high visitation, geographic significance and predicted natural pathways). Between 21 April 2010 and December 2011 surveillance was conducted on production, forestry, indigenous revegetation nurseries and high-risk highway roadside entry points into East Gippsland and north-east Victoria. Additionally, the Royal Botanic Gardens Melbourne also surveyed their Myrtaceae plants for Myrtle Rust.

Activities after detection of Myrtle Rust in Victoria

After the detection and confirmation of Myrtle Rust in Victoria on 4 January 2012, Agriculture Victoria:

1) initiated regulatory controls on infested premises during the investigation and response phase;
2) provided training, identification, market access and printed material to engage with and support industries, relevant government land managers and the public to safely prepare for and manage Myrtle Rust;
3) traced, conducted delimiting surveys, mapped and monitored its spread and host plants infected, either by site inspections, or via photographs submitted via email;
4) monitored sentinel sites for potential spread of the disease into natural ecosystems.

During inspections staff wore full protective suits (Scribal Group Pty Ltd) and carried out decontamination (foot bath with 1/10 Phytoclean™). Equipment was treated with an Australian Pesticides and Veterinary Medicines Authority (APVMA) approved surface sterilising agent Agriquat™ (PER10535) or 70% ethanol.

Tracing

After detection of Myrtle Rust in Victoria, the distribution of *A. psidii*-infected Myrtaceae host plants were traced by DEDJTR staff conducting interviews with personnel at infected premises (IPs). Follow-up of trace-forward and trace-back investigations consisted of visits to suspected sites by Agriculture Victoria in both Melbourne and regional areas. Where necessary, interstate biosecurity officers were notified of trace-forwards or trace-backs to their state.

Trace-back of plants at IP1 confirmed they had originated from a nursery in NSW, suggesting an interstate compliance failure. Given the size, incidence and extent of leaf distortions associated with the symptoms, it was considered that they were unlikely to have emerged in transit. There were 135 traces made from IPs, which included seven trace-forwards and one trace-back to South Australia and six trace-forwards and one trace-back to NSW (Fig. 1). Tracing indicates most of these IPs were associated with the movement of infected potted plants. Analysis of the surveillance data indicated there were multiple pathways of entry into Victoria. The disease was first observed in retail nurseries and within a fortnight of trace-forwards, reports led to private properties. Seven weeks after the first detection, the disease was found in 13 amenity plantings (Fig. 2). As of July 2016, Myrtle Rust had not been detected in native bushland or eucalypt plantations in Victoria (David Smith, pers. comm. July 2016).

Delimiting surveys

Delimiting surveys were conducted by Agriculture Victoria within 2 km to determine the

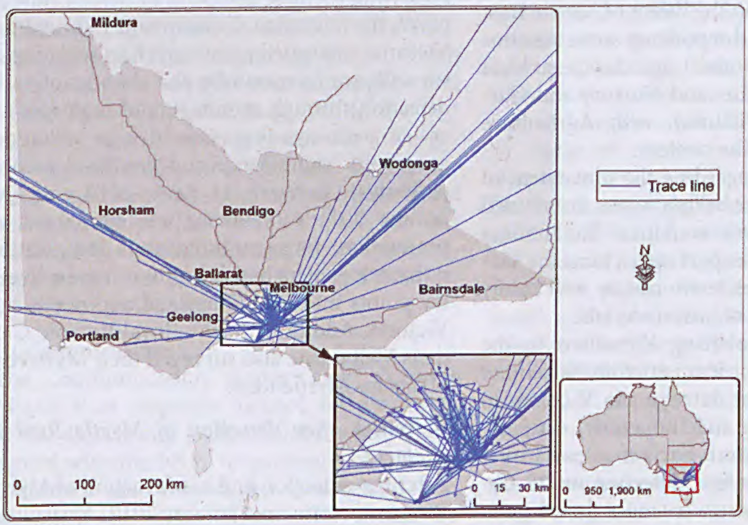
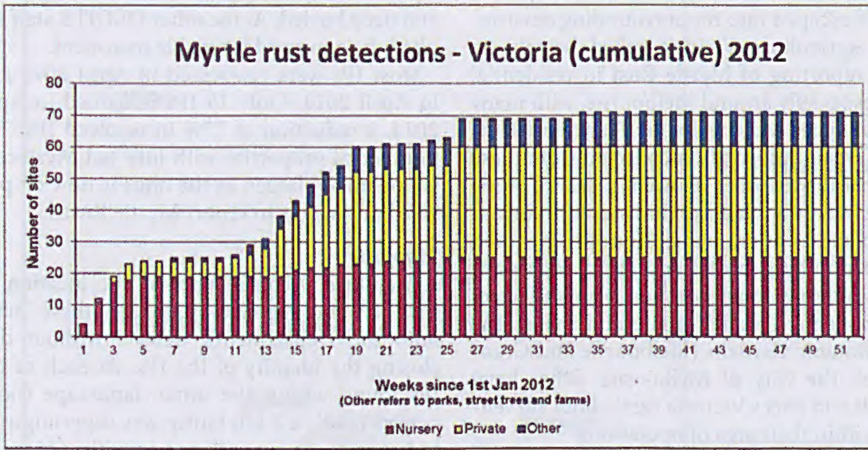


Fig. 1. Map of trace-backs of suspect Myrtle Rust as of 18 December 2012.



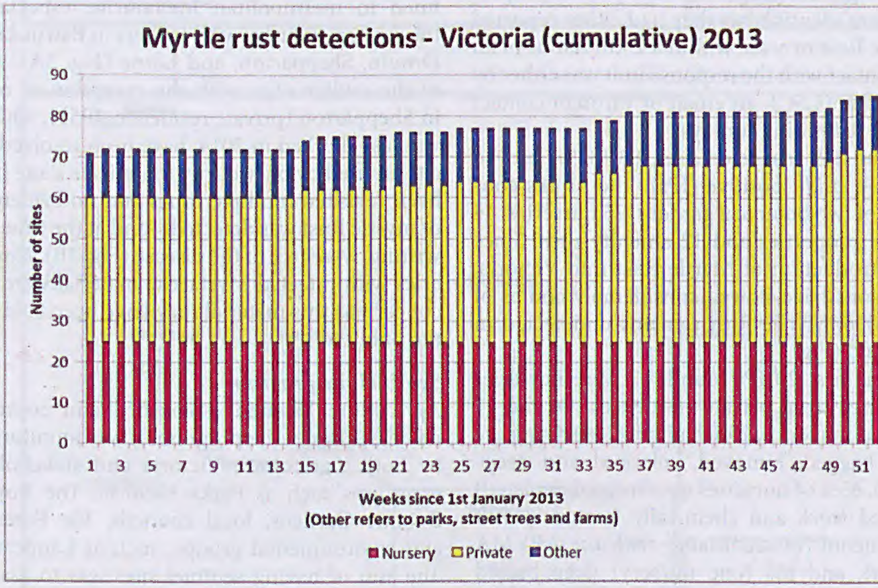


Fig. 2. Cumulative detections of Myrtle Rust in Victoria during 2012 (top) and 2013 (bottom).

extent of the outbreak and whether the pathogen had escaped into the surrounding environment. Agriculture Victoria relied heavily on public reporting of Myrtle Rust in residential areas, especially around Melbourne, with many reports logged via the Exotic Plant Pest Hotline or email. Information collected from these sites was loaded onto Bioweb, a secure Agriculture Victoria database that stored information on site location, name of property owner, contact numbers, postal and street address of site, latitude and longitude, host plants affected, correspondence, status of site and maps. The Royal Botanic Gardens (Melbourne and Cranbourne), the City of Melbourne, other local councils and Parks Victoria carried out surveillance within their area of operations.

During the response, surveillance was conducted on 154 nurseries, 20 amenity sites, multiple *Eucalyptus* plantations across Victoria, especially in the Otway Ranges and Gippsland, and 84 private properties. The private properties were identified as they had either reported Myrtle Rust or were within a 2 km radius of an IP. Contact with the response unit was either by telephone (CSC), an email or through contact during delimiting surveys.

Of the 259 inspected sites, 83 (32%) proved to be *A. psidii* positive (IPs). The 83 IPs consisted of two botanical gardens, 25 nurseries, 44 private properties and 12 amenity sites. Since the introduction of Myrtle Rust into Victoria, detections have slowed considerably and as of July 2016, Myrtle Rust remains undetected in bushland (Fig. 3).

Of the first 20 IPs found, 17 were nurseries and three were private residences. Of the 17 infected nurseries, 29% had infected Myrtaceae stock bagged, removed, solarised and deep-buried, 65% of nurseries quarantined (isolated) infected stock and chemically treated it with triadimenol (in accordance with the APVMA permit), and 6% (one nursery) deep buried the infected stock on site. One nursery closed and its consolidated plant material at another premises, well after its infected status had been resolved. Potentially a large amount of nursery stock had been distributed after the initial detection. Of the three private residences infected, two had plants bagged, removed, solarised and deep buried. At the other DEDJTR staff applied the approved fungicide treatment.

Most IPs were reassessed in April 2013 and in April 2014. Only 19 IPs remained in April 2014, a reduction of 77% in resolved IPs. The number of properties with infected Myrtaceae is potentially larger, as the onus is now on private landowners to report Myrtle Rust.

Mapping

Agriculture Victoria mapped the location of each IP and regularly uploaded these maps onto the Department's website without disclosing the identity of the IPs. At each of the IPs found within the urban landscape (non-commercial), a 2 km buffer was superimposed to better focus surveillance activities. Maps of locations of each infected property enabled the spread of the disease to be tracked and aided in planning treatments. Mapping of the Myrtle Rust detections showed they were largely confined to metropolitan Melbourne, especially the eastern suburbs, with outliers in Bairnsdale, Drouin, Shepparton, and Lorne (Fig. 3A). All of the outlier sites, with the exception of one in Shepparton (private residence, IP51), which was last checked in 2014, have been resolved—a term used by biosecurity to indicate a site has been revisited multiple times and no evidence of myrtle Rust was detected—and at the time of writing, were free of the disease (Fig. 3B). Nurseries with infected Myrtaceae material were of concern as this material may have been sold to the public.

Sentinel site program

Agriculture Victoria established and coordinated a sentinel site program. It was monitored by both Agriculture Victoria and stakeholder groups such as Parks Victoria, The Royal Botanic Gardens, local councils, Vic Forests and environmental groups, such as Landcare. The aim of having sentinel sites was to assist with the early detection of Myrtle Rust outside of areas where the disease had been confirmed. Sentinel sites were locations which:

(i) were frequently visited by the general public;
(ii) had high risk vegetation classes;

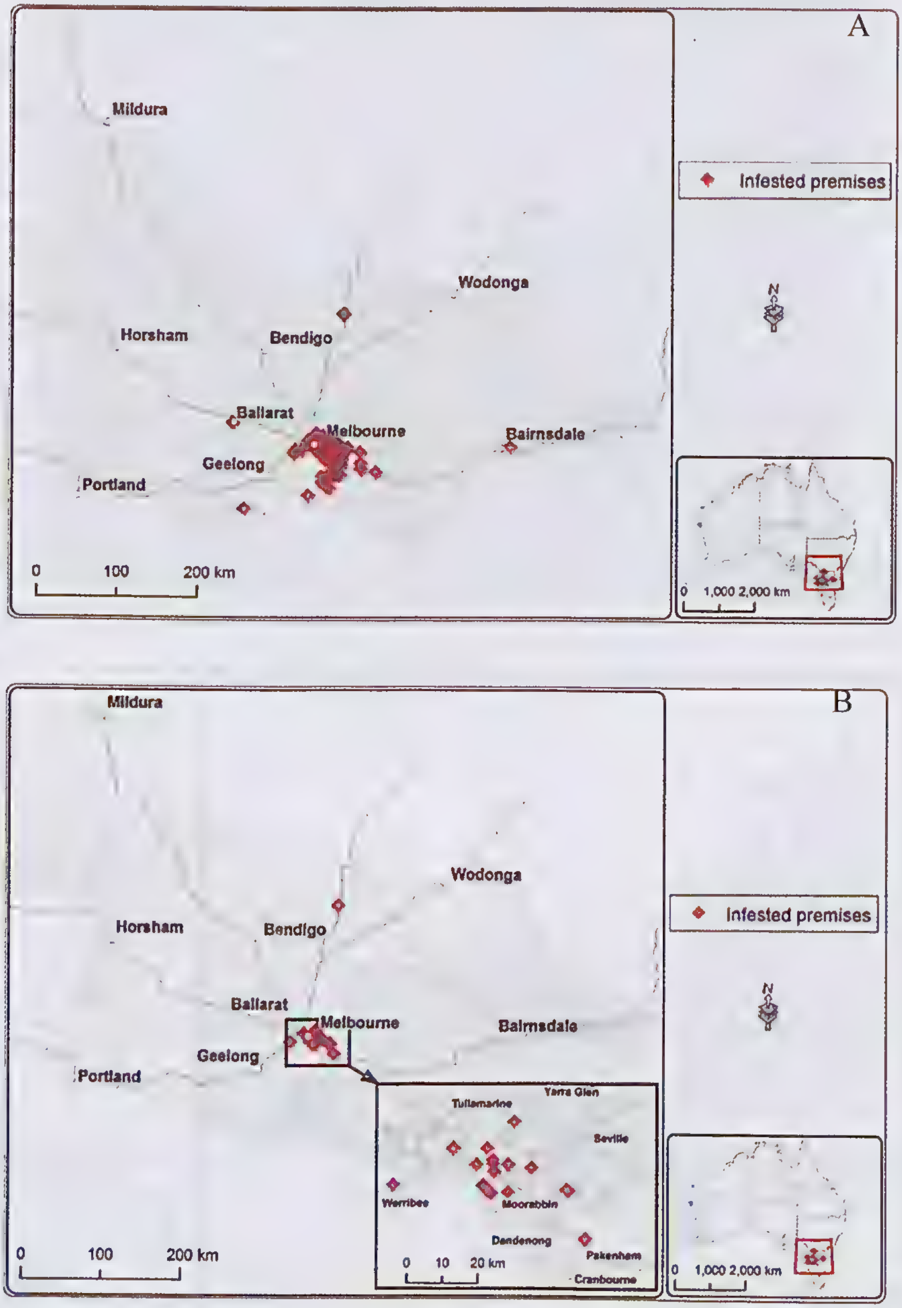


Fig. 3. Maps showing (A) the total number and location of sites that tested positive for *Austropuccinia psidii* up to April 2014 and (B) the number and location of sites that remained positive for *A. psidii* at April 2014.

(iii) had a high likelihood of spores landing on a susceptible host; and
(iv) could be easily and regularly monitored by selected stakeholders.

Sentinel sites were located at botanic gardens, roadside stops, Landcare sites, high-use public parks and picnic sites, significant bushland sites and privately managed assets. Sentinel sites were established at 175 locations (Fig. 4) and site monitors were requested to report monthly. The early identification of Myrtle Rust in a public Parks and Gardens site in south-eastern Melbourne was a result of one such sentinel site. By 2014, many sites ceased to report negative data. From 2014, Agriculture Victoria only monitored sentinel sites in East Gippsland, on the border with NSW, in autumn and spring, as these seasons were found to be conducive for new reports of the fungus in Victoria. Since May 2016, monitoring of the East Gippsland sentinel sites was abandoned due to lack of detection of the Rust.

Diagnostics

Identification of Austropuccinia psidii

An outer-suburban metropolitan nursery was the first to report a suspect *A. psidii* sample. Agriculture Victoria's surveillance staff collected and transported samples to Agriculture Victoria's plant diagnostic laboratory, Crop Health Services, Melbourne. Standard procedure in the event of suspect new pathogen incursions involves secondary confirmation testing by a second diagnostic laboratory. Crop Health Services had conducted the secondary confirmatory testing for the initial detections of *A. psidii* in NSW and Queensland and were therefore experienced in *A. psidii* diagnostics. Interim diagnosis of the first Victorian *A. psidii* specimen was based on host identity, disease symptoms and Rust spore morphology (Fig. 5). Final definitive diagnosis was based on species-specific molecular tests and DNA sequencing. The turn-around time for the interim diagnosis was less than 24 hours, with the definitive DNA diagnosis completed seven days later due

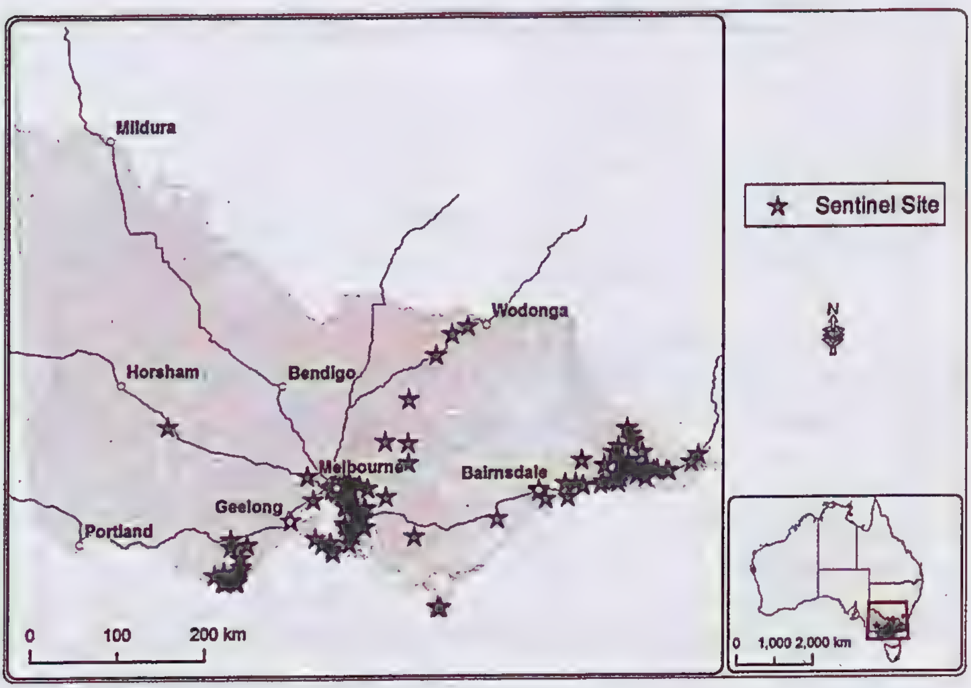


Fig. 4. Map of sentinel sites established within Victoria for regular monitoring of *Austropuccinia psidii.*

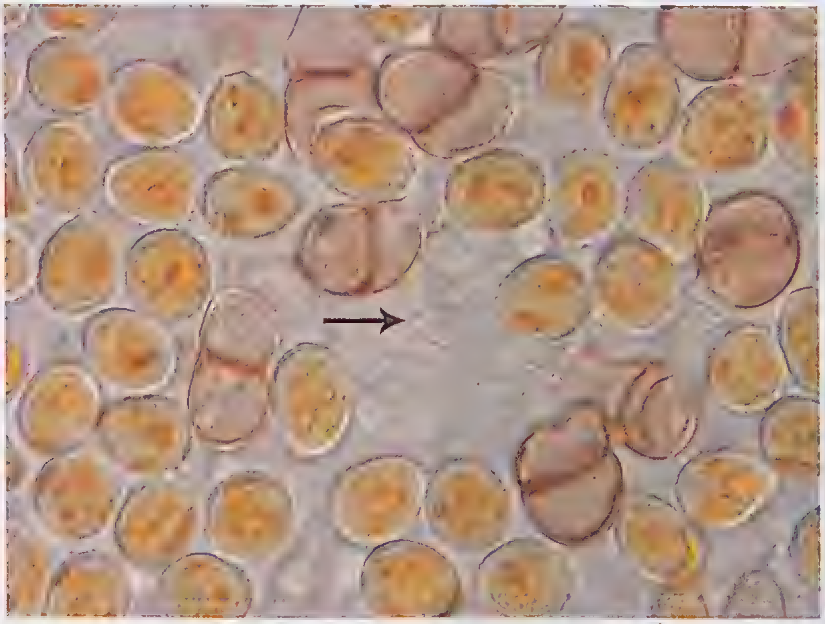


Fig. 5. *Austropuccinia psidii* single-celled? urediniospores (yellow), teliospores (brown) and basidiospores (colourless, arrowed) from infected *Lophomyrtus* sp., using oil immersion (x 1000) on a Leica compound microscope.

to DNA sequencing facilities being closed over the holiday period. To date only the pandemic strain of *A. psidii* has been detected in Victoria (Machado *et al.* 2015).

Subsequent identification of suspect *A. psidii* samples was initially made by Agriculture Victoria from photographs submitted by email or via field surveillance staff. A sample of symptoms was then collected from each IP and sent to Agriculture Victoria Crop Health Services for confirmation as described above. Later, due to confidence in diagnoses, identifications were made solely by Agriculture Victoria biosecurity pathologists based on visual symptoms. Identification of *A. psidii* based on symptoms of the disease supplied in photographs submitted via email was a successful method to filter out non-Myrtaceae host material from the response. On Myrtaceae hosts, in many cases, uredospore production was prolific and the 'egg-yolk' yellow colour distinctive enough to make identification of the disease via digital photographs practical (Fig. 6).

If there was any doubt about the identification of symptoms, the reporting person was asked to post a sample to Agriculture Victoria, which then referred it to Crop Health Services for examination. In these cases, the diagnosticians would moist-incubate the specimen to induce sporulation as well as perform DNA extraction and DNA sequencing of the symptomatic tissue. If both methods proved negative, Crop Health Services reported that the symptoms were most likely not caused by *A. psidii* and Agriculture Victoria would advise the landowner to examine and monitor the plant. If no sporulation was found on the suspect host after extensive examination and the landowner reported that none was found after several weeks of observations, it was assumed the symptoms were not caused by *A. psidii*.

Host range in Victoria

There were 11 known genera of Myrtaceae and up to 28 known species and or plant varieties showing symptoms of Myrtle Rust in Victoria (Table 2). Many sites contained multiple species with symptoms of Myrtle Rust. Of the 83 IPs, *Lophomyrtus* x *ralphii* 'Black Stallion' occurred on 26 sites, *Agonis flexuosa* 'Nana' on 15, Lilly

Fig. 6. *Austropuccinia psidii* bright yellow urediniospores produced on *Lophomyrtus* sp.

Pilly (genus not recorded) on nine, and Myrtaceae (genus not recorded or unknown) on eight sites, *Lophomyrtus* sp. (species not determined) and *Myrtus communis* each occurred on seven sites, while *Syzygium paniculatum* and *Lophomyrtus* x *ralphii* 'Rainbows End' each occurred on four sites. All other hosts were found on only three or fewer sites.

The most frequently infected host was *Lophomyrtus* x *ralphii* 'Black Stallion'. One site had more than 3000 nursery plants with symptoms. Many reports of Myrtle Rust were on hedges of *Lophomyrtus* x *ralphii* 'Black Stallion', on hedges or clipped plants of *M. communis* and on *A. flexuosa* 'Nana' grown in rows or as individual plants on private properties. Of the 83 sites with Myrtle Rust, 35% (29 sites) were on hedges. Of the species listed in Table 2, only *Callistemon subulatus* and *Syzygium smithii* are native to Victoria.

Management and control

Private residents with *A. psidii*-infected Myrtaceae, especially hedges, were advised to apply one of three options: (i) remove the hedge, solarise the infected plant material and replant with non-Myrtaceae hosts; (ii) spray foliage with water to stop spores becoming airborne, prune off all infected plant parts and spray infected plants with an APVMA-approved fungicide (triadimenol or Zaleton™); or (iii) spray repeatedly with APVMA-permitted or registered fungicides until the Rust was eradicated. Home owners were encouraged to undertake the first option, and many chose this as they did not want to use chemicals repeatedly.

The public responded well to options for management, especially for sites where destruction of infected material was unacceptable to the home owner or nursery. Fungicide sprays appeared to contain the spread of the disease within nurseries. Home owners with infected Myrtaceae hedges often chose to remove the hedge and replant with non-Myrtaceae plants. Agriculture Victoria continues to monitor the plant pest hotline and provide options for the public to contain and control Myrtle Rust.

Discussion

Symptoms of Myrtle Rust in Victoria were first reported to Agriculture Victoria on 28 December 2011 by a retail nursery, whose staff noticed Myrtle Rust on a consignment of potted Myrtaceae plants originating from a supplier in NSW. It spread rapidly from nurseries to residential sites by human-assisted movement of potted plants and then by natural spread to amenity plants, but has not become well established in either home gardens or amenity plantings in Victoria. Myrtle Rust has not been reported in native ecosystems. It is possible that the temperate climatic conditions in Victoria are not conducive to establishment of *A. psidii,* which is a tropical Rust considered to have emerged in Brazilian rainforests (Coutinho *et al.* 1998; Tommerup *et al.* 2003; Alfenas *et al.* 2005). The pockets of warm temperate rainforest in East Gippsland are an exception. If *A. psidii* found its way into this ecosystem, it is probable that this Rust could cause considerable damage. The Victorian situation is in contrast with that of NSW and Queensland, where the *A. psidii* range is still spreading, native Myrtaceae are at risk of extinction and whole ecosystems are threatened (Carnegie and Lidbetter 2012; Pegg *et al.* 2014; Carnegie *et al.* 2016).

Table 2. List of hosts of *Austropuccinia psidii* in Victoria and the number of sites at which they were detected.

Myrtle Rust host		Number of sites with an infected host
Taxa	Common name	
Agonis sp.	Willow Myrtle	2
Agonis flexuosa	Willow Myrtle	2
Agonis flexuosa 'After Dark'	Willow Myrtle	1
Agonis *flexuosa* 'Burgundy'	Willow Myrtle	1
Agonis *flexuosa* 'Nana'	Willow Myrtle	15
Agonis flexuosa 'Variegata'	Willow Myrtle	2
Austromyrtus dulcis	Midgen berry/Midyim	1
Backhousia citriodora	Lemon-scented Myrtle	3
Chamelaucium uncinatum	Geraldton wax	1
Callistemon 'Harkness'	Bottlebrush	1
Callistemon subulatus	Bottlebrush	1
Callistemon viminalis	Bottlebrush	1
Callistemon 'Kings Park Special'	Bottlebrush	1
Eucalyptus olida	Strawberry gum	1
Lilly Pilly (genus unknown)	Lilly Pilly	9
Lophomyrtus sp.	N/A	7
Lophomyrtus obcordata	Rohutu	1
Lophomyrtus x *ralphii* 'Black Stallion'	N/A	26
Lophomyrtus x *ralphii* 'Krinkly'	N/A	3
Lophomyrtus x *ralphii* 'Little Star'	N/A	1
Lophomyrtus x *ralphii* 'Rainbows End'	N/A	4
Metrosideros excelsa	Pōhutukawa	1
Metrosideros collina 'Fiji'	Fiji Christmas bush	1
Myrtaceae	N/A	8
Myrtus sp.	N/A	1
Myrtus communis subsp. *romana*	Common Myrtle	7
Syzygium spp.	N/A	1
Syzygium anisatum	Aniseed Myrtle	1
Syzygium australe	Bush Cherry	2
Syzygium australe 'Aussie Southern'	Bush Cherry	2
Syzygium australe 'Resilience'	Bush Cherry	1
Syzygium australe 'Winter lights'	Bush Cherry	1
Syzygium paniculatum	Magenta Cherry	4
Syzygium smithii	Lilly Pilly	1

In regional Victoria, the predicted risk of climatic conditions conducive to Myrtle Rust development on native vegetation was described as low by Booth and Jovanovic (2012) and Kriticos *et al.* (2013). In Melbourne, it was described as low by Booth and Jovanovic (2012), but Kriticos *et al.* (2013) predicted Myrtle Rust development on myrtaceous vegetation was greater for the area east of Melbourne. The majority of IPs were reported in the area east of Melbourne, but reporting of IPs relied heavily on a public response. The watering regime of home gardeners and the planting of Myrtaceae hedges, with dense canopies of susceptible young growth, which could retain moisture, could provide ideal conditions for fungal infection.

In Victoria, temperature conditions conducive for infection by *A. psidii*, such as 15 °C to 23 °C at night with high humidity or leaf wetness (Kriticos *et al.* 2013, Ruiz *et al.* 1989), are rarely met in Melbourne. The authors have noticed (since Myrtle Rust established in Victoria) that when night temperatures of 15 °C to 23 °C are predicted to occur and leaf wetness in the form of rainfall or dew is expected to occur overnight, new reports of Myrtle Rust symptoms usually followed about a fortnight later.

Symptoms of Myrtle Rust were most frequently observed on *Lophomyrtus* x *ralphii*

'Black Stallion', *Agonis flexuosa* 'Nana' and *Myrtus communis*, but this may well reflect their more frequent plantings. *L.* x *ralphii* and *M. communis* are frequently grown as hedges and *A. flexuosa* 'Nana' is a squat compact bush. *Austropuccinia psidii* infects susceptible young plant tissue (Glen *et al* 2007). The growth characteristics of these plants encourages the production of dense young stems and leaves, which in turn encourages retention of humidity and leaf wetness within the canopy, especially at night, thus providing ideal conditions for *A. psidii* infections. Several hosts reported in Victoria were new host records for Australia (Carnegie and Lidbetter 2012; Pegg *et al.* 2014): *Lophomyrtus obcordata*, *Callistemon* 'Harkness' and *C. subulatus*.

Although the first detection of Myrtle Rust in Victoria was at a retail nursery, unfortunately the names of plants were not recorded accurately and, additionally, the accuracy of labels may be questionable. Following the initial detection, the reporting of symptoms of Myrtle Rust in Victoria has relied on the public and systematic surveys around IPs. The extensive communications package and media coverage prompted many enthusiastic public reports, but many turned out to be other Rusts or other symptoms on non-Myrtaceae hosts. Accurate identification of the host is often difficult but is important.

Media releases both before and after the detection in Victoria generated significant interest amongst newspaper and radio outlets. Regular meetings of the Myrtle Rust Coordination Committee were an important tool in keeping the key industries and agencies informed of progress and providing them with a sense of ownership of the response. Special interest groups such as Landcare and plant societies were and remain enthusiastic and are important conduits for information distribution as is the continuing response from Queensland and NSW (Carnegie *et al.* 2016; Pegg *et al.* 2014).

The confirmation of *A. psidii* in Victoria was on 4 January 2012 and by 20 January 2012 20 IPs were confirmed. There was a rapid identification of a large number of IPs through tracing and public reports. *Austropuccinia psidii* spread from nurseries to residential plantings within a fortnight, then spread naturally to amenity plantings, within seven weeks of the initial detection. The large number and well dispersed locations of IPs suggested management was the most likely means of containment for a fungus with airborne urediniospores.

Acknowledgements

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Sixty Years Ago

THE CHALLENGE OF A CHANGING SCENE

BY J. H. WILLIS

… It behoves every naturalist to keep systematic records of the plant and animal life around him—local lists of species and forms, flowering and seeding habits, migration patterns, life histories of as many organisms as possible (and we know remarkably few as yet). How fascinating it can be to study the sequences in any plant species—budding, flowering, fruiting, germinating, methods of pollination, evidences of hybridism—or the courtship and nesting habits among birds and insects, food preferences, effects of climate and local weather, incidence of disease, resistances to it. Why, the sky is the limit to any naturalist keen enough to observe the passing scene around him; but he must have some method of recording what he sees. So often the most vital secrets die with the one who discovered but failed to note, them down for the benefit of posterity…

From *The Victorian Naturalist* **76**, p. 204, December 10, 1959

A stable aggregation of Red-naped Snakes *Furina diadema* under an artificial retreat site

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Abstract
On a rural property near Menangle, New South Wales, a sheet of corrugated iron set over an earth mound provided a retreat site for the Red-naped Snake *Furina diadema*. The site was inspected on 14 occasions over a period of 32 months, each time revealing an aggregation of between six and eight snakes. Seasonality did not appear to influence the number of snakes present. Based on the consistency of these observations, the aggregation may be the first stable aggregation of the Red-naped Snake reported in the scientific literature. (*The Victorian Naturalist*, **136** (5), 2019, 174–177)

Keywords: communal site, corrugated iron, cracks in soil, Elapidae, *Furina diadema*

Introduction

Snakes are generally not social animals, such that aggregations tend to occur when retreat habitat is limited (Shine 1993). In cold climates, retreat sites may attract large aggregations of snakes as a function of animals over a broad area being forced to share these sites (Gregory 2004; Martínez Vaca-León *et al.* 2019). In Australia, aggregations are less frequently found (Shine 1979; Scanlon and Davidson 1999; Peck 2000; Anderson *et al.* 2005; Scott *et al.* 2013). They are generally associated with reproductive activity or natural disasters prompting displaced snakes to seek new retreat sites (Shine 1993; Bedford and Comber 2000; Turner 2001; McKay and Crase 2005). Of these, there were few cases where the aggregation occurred over an extended period of time (e.g. Fitzgerald 2000), and fewer that have been recorded occurring over multiple years (e.g. Schembri 2007).

The Red-naped Snake *Furina diadema* (family Elapidae) is a small, mildly-venomous snake of slender build found in drier habitats in eastern Australia (Cogger 2018). It is nocturnal, living predominantly under debris and in cracks in soil, where it locates small lizards as prey. Aggregations of this species have been found occasionally (Swan 1990), including one report of an adult Red-naped Snake found coiled amongst two Yellow-faced Whipsnakes *Demansia psammophis* (G Webb in Hoser 1980). However, it is not known whether these aggregations occurred over an extended period of time.

Here, I report observations of an apparently stable aggregation of Red-naped Snakes under a sheet of corrugated iron.

Observations

The observations were made on a rural property used for cattle grazing near Menangle in the Southern Highlands, south-west of the Sydney metropolitan area. The aggregation of snakes was first located during an inspection of artificial materials left on the property. The site was 30 m from a farm dam with scattered trees along its perimeter. The snakes were sheltered beneath a 2 m x 2.5 m sheet of corrugated iron, which was left on the top of a mound of earth (Fig. 1). A series of cracks within the soil were present beneath the corrugated iron, and may have existed before the corrugated iron was laid down.

The site was inspected 14 times between May 2014 and January 2017. Snakes were present each time, ranging from six to eight individuals (Table 1). Each visit was conducted between 1200 h and 1300 h, during which ambient temperatures ranged from 18 °C to 29 °C. Ambient temperatures did not appear to influence the number of snakes recorded. The edges of the corrugated iron were checked for animals at each visit to avoid causing injuries when the structure was lifted and flipped.

Once exposed, snakes were counted swiftly before some disappeared into cracks present within the soil. Some snakes were exposed either on bare ground, needing to slither to the nearest crack (Fig. 2), or retreated into small depressions in the ground (Fig. 3). The skeletal remains of one snake were discovered on the first visit (see front cover), and were present

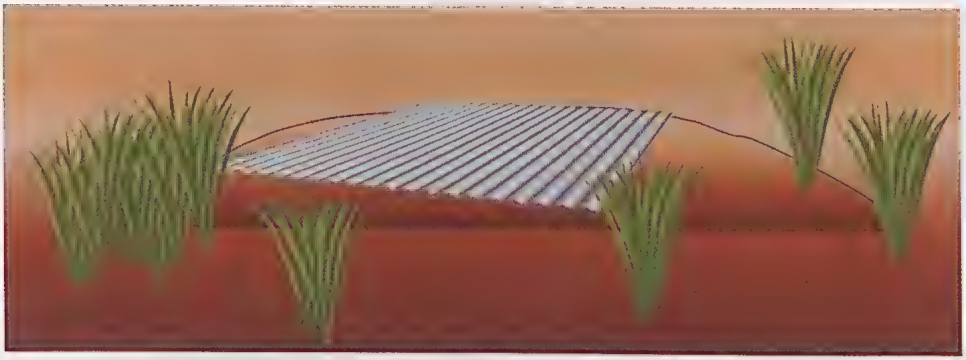

Fig. 1. A representation of the aggregation site beneath a sheet of corrugated iron set over an earth mound.

Table 1. Numbers of Red-naped Snakes observed at the study site over 14 visits.

Date of visit	Ambient temperature	No of snakes
6 May 2014	21 °C	7
4 Jun 2014	22 °C	6
14 Aug 2014	19 °C	7
17 Oct 2014	21 °C	8
19 Dec 2014	25 °C	6
4 Feb 2015	25 °C	8
7 May 2015	19 °C	7
12 Nov 2015	25 °C	8
8 Dec 2015	26 °C	7
18 Mar 2016	29 °C	8
14 Apr 2016	23 °C	8
29 Jun 2016	18 °C	6
1 Sep 2016	22 °C	8
4 Jan 2017	26 °C	7

on each repeat visit. Given that no other species was recorded, the remains were presumably those of a Red-naped Snake. The sheet of corrugated iron was gently replaced in the same position after each inspection.

Closing remarks

Situations where multiple snakes are recorded together over extended periods of time have been termed 'stable aggregations' (Gardner *et al.* 2015). Based on the consistent number of snakes found, it is reasonable to consider that the aggregation here represents a stable aggregation. Furthermore, seasonality did not appear to influence the numbers of snakes present. To the best of my knowledge, no other aggregation of Red-naped Snakes over multiple years has been reported in the scientific literature.

It is possible that the site harbours a number of transient individuals, rather than the same aggregation of snakes. This could not be determined because none of the snakes had unique characteristics to individually identify them. Furthermore, the snakes were not captured and marked because of considerations to minimise disturbance.

The reasons for aggregation in this species are not clear (Swan 1990). The aggregation may have been a function of there being few retreat opportunities adjacent to this large retreat site. As seen elsewhere (Barton *et al.* 2011), herbivore grazing on the property had resulted in a reduction in logs and other ground debris, through the the practice of clearing. The corrugated iron possibly provides additional protection from ambient conditions and predation risk superior to other retreat sites (cf. Murphy 2016; Bourke *et al.* 2017), while the elevated mound reduces the chances of earth cracks being severely inundated during heavy rains. There may also be a reproductive benefit to aggregating, as suggested by observations of other species (Scanlon and Davidson 1999; Bedford and Comber 2000; Turner 2001; McKay and Crase 2005).

Acknowledgements

The property owners permitted access to their land, which made repeat visits possible. Two anonymous referees provided useful comments that improved this manuscript and assisted in locating relevant literature.

Fig. 2. A Red-naped Snake *Furina diadema* seeks out an earth crack after the sheet of corrugated iron was lifted. Photo M Mo.

Fig. 3. A Red-naped Snake *Furina diadema* retreated in a small ground depression. Photo M Mo.

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One Hundred and One Years Ago

TWO SNAKES NEW TO VICTORIA, WITH A LIST OF THE VICTORIAN SPECIES

BY J. A KERSHAW, F.E.S., Curator of the National Museum, Melbourne

(*Read before the Field Naturalists' Club of Victoria, 14th Jan., 1918*)

Two species of snakes not previously recorded from Victoria have been recently added to the National Museum collection, both of which were captured in the Mallee, in the north-western portion of the State. These I have been able to identify as *Rhynchelaps australis*, Krefft, and *Denisonia nigrostriata*, Krefft. The former was described from specimens obtained in the neighbourhood of Port Curtis, Queensland, and on the Clarence River, northern New South Wales, and the latter has been recorded from Rockhampton, Queensland …

The total number of snakes recorded from Victoria, including the Typhlopidae (Blind Snakes) and excluding two doubtful Victorian species – viz., *Dendrophis punctatus* and *Denisonia signata* (recorded by Mr. D. Le Souëf in vol. i., 1884, p. 86, of this journal) – is now twenty-six. Of these, *Denisonia nigrescens*, Krefft, recorded for the first time in Victoria in the *Vict. Nat.*, vol. xxv. (1908), p. 91, has since been taken at Cunninghame and Bruthen, in Eastern Gippsland, and at least four specimens of the Yellow-bellied Sea-Snake, *Hydrus platurus*, Linn., are known to have been taken in Victorian waters …

From *The Victorian Naturalist* **XXXV**, PP. 30-31, June 6th1918

Survival of mammal populations in a small, isolated native vegetation block following severe wildfire in the La Trobe Valley, Victoria

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Abstract
An isolated 31 hectare block of native vegetation in the La Trobe Valley, Victoria was severely impacted by wildfire in February 2014. Despite 90% of the block being burnt, all native mammal species recorded during studies in 2007 and 2011, as well as several additional species, were recorded during a post-fire survey in October 2018. The results from the 2018 post-fire survey showed that terrestrial and arboreal native mammal communities were able to survive wildfire, provided that suitable refuges remained unburnt. The results also showed that small areas of native vegetation could provide important habitat, especially across fragmented landscapes. (*The Victorian Naturalist* **136** (5), 2019, 178–183)

Keywords: mammals, terrestrial, arboreal, isolation, refuges

Introduction

Numerous off-set areas, set aside for conservation purposes under agreements with the Victorian Government, exist around the Yallourn coal mine in the La Trobe Valley, Victoria (Department of Natural Resources and Environment 2002). Since 2007, monitoring of fauna populations has been conducted in these areas (Homan 2009; Homan unpubl. data).

One area of approximately 31 hectares is situated on the eastern side of the coal mine, about 4.5 km north of the township of Morwell. The area is completely isolated from other native vegetation, with the nearest equivalent habitat approximately 8 km to the north in the Tyers Regional Park on the north side of the La Trobe River. The study area is covered by Natmap 1:100,000, Sheet No. 8121 (Moe). The Map Grid of Australia coordinates for the central point of the area are 470E and 721N.

Under the Yallourn Mine Conservation Management Plan (YMCMP) this area is known as 'Blocks 4 and 5'. Most of the area is on a gentle slope (Block 5) above a fairly narrow, damp gully (Block 4). These two blocks contain three Ecological Vegetation Communities: Plains Grassy Forest on the slope (27 hectares) with Riparian Forest (two hectares) and Swampy Riparian Complex (two hectares) in the damp gully (Homan 2009). In February 2014 a severe bushfire, known as the Morwell Fire, burnt approximately 90% of the area (Fig. 1). About one hectare at the northern end of the gully (Fig. 2),

Fig. 1. Impact of fire February 2014, Block 5. Photo courtesy of Indigenous Design Environmental Management.

Fig. 2. Unburnt sedge vegetation in gully, Block 4.

a line of old-growth eucalypts on the northern fringe and numerous old-growth eucalypts in a side gully (Fig. 3) remained unburnt.

Monitoring of fauna populations occurred over four days and three nights in March 2007 (Homan 2009), March 2011 (Homan unpubl. data) and 29 October 2018 to 1 November 2018. The surveys were commissioned by TRU Energy Pty Ltd and EnergyAustralia Pty Ltd and were conducted by Peter Homan Fauna Consultancy.

Methods

Several methods were used to detect the presence of mammals. These included Elliott trapping, Type A (Elliott Scientific Equipment, Upwey, Victoria), cage trapping, standard bandicoot cage traps (Wiretainers Ltd, Preston, Victoria), harp trapping (Ecological Consulting Services, Newport, Victoria and Faunatech, Bairnsdale, Victoria), remote surveillance cameras (Scoutguard Models DTC-530, KG-680V and SG-990V, China and Faunatech Snap, Faunatech, Bairnsdale, Victoria), bat detector, Anabat Express (Titley Electronics, Ballina, NSW), stagwatching, spotlighting and general observation.

During the 2007 survey, cage trapping was restricted to the main gully area (Homan 2009). Elliott trapping in 2007 was conducted in the main gully, a small side gully and across the adjoining Plains Grassy Forest slope (Homan 2009). Elliott trapping in 2011 followed the same design as in 2007. During the 2018 survey most Elliott traps were set in the main gully and the side gully (one continuous line of 50 traps, 10 m apart) with smaller numbers on the adjoining slope (one line of 10 traps, 10 m apart). Cage trapping ceased after the 2007 survey and was replaced with surveillance cameras in the two subsequent surveys. Baits for live trapping consisted of a mixture of quick oats, smooth peanut butter and golden syrup.

Fig. 3. Unburnt eucalypts, side gully, Block 5.

During the 2011 survey, three cameras were set 20 m apart in the main gully and three were set 50 m apart across the dry slope. During the 2018 survey, 12 cameras were set 20 m apart in the main gully and the adjoining side gully, with four cameras set 50 m apart on a section of the dry slope. Baits for cameras were the same as for live trapping. The use of a bat detector was introduced during the 2018 post-fire survey. Overall, 710 trap-nights were completed, 480 pre-fire and 230 post-fire (Table 1).

Results

Fifteen species of mammals were recorded pre-fire in 2007 and 2011. These comprised one monotreme, six marsupials and eight eutherians. Twelve species were native and three were introduced (Table 2).

Eighteen species were recorded during the 2018 post-fire survey. These comprised one monotreme, eight marsupials and nine eutherians. All species were native (Table 2).

Discussion

Numerous studies have been conducted in south-eastern Australia covering the survival and recolonisation by mammals following fires of varying intensity (Newsome *et al.* 1975; Lunney *et al.* 1987; Catling *et al.* 2001; Recher *et al.* 2009; Homan 2012). Previous studies have generally covered large areas of contiguous native vegetation where species were able to recolonise from surrounding unburnt areas or where numerous unburnt refuges remained (Wilson

Table 1. Survey methods and effort completed pre- and post-wildfire.

Survey method	2007	2011	2018
Elliott trap-nights	192	180	180
Cage trap-nights	78		
Harp trap-nights	6	6	3
Surveillance camera-nights		18	44
Bat detector nights			3
Stags watched	2	9	6
Spotlight hours	4.5	6	9

Table 2. List of mammal species and number recorded pre- and post-fire. (i: indirect evidence; e: estimated number). Method column indicates successful survey technique for 2018 survey (E: Elliott trap; C: camera; B: bat detector; H: harp trap; S: stagwatching/spotlighting; G: general observation)

Common Name	Scientific Name	2007	2011	2018	Method
Short-beaked Echidna	*Tachyglossus aculeatus*	i	i	1	C
Agile Antechinus	*Antechinus agilis*	23	3	1	E
Bare-nosed Wombat	*Vombatus ursinus*	i	i	2	C, S
Koala	*Phascolarctos cinereus*			1	G
Sugar Glider	*Petaurus breviceps*		4	3	S
Common Brushtail Possum	*Trichosurus vulpecula*			1	C
Eastern Ringtail Possum	*Pseudocheirus peregrinus*	22	14	42	S
Eastern Grey Kangaroo	*Macropus giganteus*	5	6	30e	G
Swamp Wallaby	*Wallabia bicolor*	3	4	25e	C, G
White-striped Freetail Bat	*Tadarida australis*			1	B
Eastern Freetail Bat	*Mormopterus ridei*			1	B
Gould's Wattled Bat	*Chalinolobus gouldii*	1	1	1	B
Chocolate Wattled Bat	*Chalinolobus morio*			1	B
Large Forest Bat	*Vespadelus darlingtoni*			2	B, H
Little Forest Bat	*Vespadelus vulturnus*	5	1	1	B
Lesser Long-eared Bat	*Nyctophilus geoffroyi*	2	4	1	H
House Mouse	*Mus musculus*		5		
Swamp Rat	*Rattus lutreolus*		3	4	E, C
Bush Rat	*Rattus fuscipes*	5	16	31	E, C
European Rabbit	*Oryctolagus cuniculus*		1		
European Hare	*Lepus europeaus*		2		

and Moloney 1985; Catling 1986; Stevens 2008; Burns *et al.* 2016). There are, however, no available studies that cover small, isolated areas of habitat, in heavily fragmented landscapes that also provide both pre-fire and post-fire data.

Since surveys began in the YMCMP blocks in 2007, survey techniques to determine the presence of mammals have changed markedly. The use of remote surveillance cameras is now a standard survey method, which has generally replaced cage trapping, especially when survey designs do not require the collection of extra information including sex, breeding condition, biometric data or genetic analysis (Meek and Fleming 2014). Cameras also have the ability to record a wide range of taxa, especially when set to record images day and night over an extended period (De Bondi *et al.* 2010; Drury 2017; Bryant *et al.* 2018). During the pre-fire surveys in 2007 and 2011, the only evidence of the presence of Bare-nosed Wombat and Short-beaked Echidna were diggings, burrows and scats.

With the increased use of cameras during the 2018 post-fire survey, both species were recorded by surveillance camera. In 2018 a surveillance camera also detected a Common Brushtail Possum, a species not recorded during stagwatching or spotlighting pre- or post-fire.

In the last decade, bat detectors (devices which record the echolocation calls of insectivorous bats) have become a common tool when surveying for the presence of micro bats (Churchill 2008). Bat surveys often combine live-trapping using harp traps with the additional use of bat detectors. During the pre-fire surveys several ideal sites to set harp traps existed along a disused four-wheel drive track. However, these sites were destroyed by the 2014 fire and, during the post-fire survey, only one site was suitable for harp trapping. Harp trapping pre-fire produced records of three species of insectivorous bats and post-fire produced records of two species. A bat detector was used for the first time in 2018, resulting in the positive identification of six species, four of which were not recorded pre-fire. However, some bat calls cannot be identified to species level and consequently numerous call images could only be identified to call complex level. These were Yellow-bellied Sheathtail Bat *Saccolaimus flaviventris*, Eastern False Pipistrelle/Broad-nosed Bat *Falsistrellus tasmanienis/Scotorepens* sp., Long-eared Bat *Nyctophilus* sp. and Forest Bat

sp. *Vespadelus darlingtoni/V. regulus/V. vulturnus*. Nevertheless, the bat detector results from the 2018 survey show that this method is a very useful tool when surveying for the presence of insectivorous bats, especially when few sites exist for harp traps. Insectivorous bats are known to fly long distances from roost sites to foraging areas especially in fragmented landscapes (Lumsden *et al.* 2002). Whilst numerous bats were seen at dusk during stagwatching, it is unclear whether or not all the bats recorded in 2018 actually roosted in these blocks.

All three small terrestrial native mammals, Agile Antechinus, Bush Rat and Swamp Rat, recorded pre-fire in 2007 and 2011, were recorded post-fire in 2018. Unfortunately, the post-fire survey could not be conducted at the same time of year as the previous studies. Therefore, it is inappropriate to compare trapping rates, especially given the short life cycle of the Agile Antechinus (Menkhorst 1995). Nevertheless, the significant number of Bush Rats captured in Elliott traps, and detected by camera shows that the population of this species was substantial by the spring of 2018.

Whilst fewer Swamp Rats were detected post-fire by live trapping and cameras, the typical burrows and runways constructed by this species were found in several grassy areas on the drier slope, well above the damp gully. It is interesting to note that these areas were severely burnt in 2014 and that no evidence of Swamp Rat was found at these sites in 2007 and 2011. Recher *et al.* (2009) found Swamp Rat had recolonised grassy vegetation two years after intense wildfire in the Nadgee Nature Reserve in New South Wales. In western Victoria, Swamp Rats survived severe wildfire in a small, unburnt refuge in Damp Sands Herb-rich Woodland and had recolonised all surrounding suitable habitat within five and a half years (Homan 2012). Other studies have shown that small, terrestrial native mammals are able to survive wildfire provided that unburnt areas of suitable habitat remain (Wilson and Moloney 1985; Catling 1986). Breed and Ford (2007) stated that pockets of unburnt habitat are particularly vital for the Bush Rat as the species tends to disperse only short distances. Fortunately, the small area of unburnt dense sedge vegetation in Block 4 was ideal habitat for the Bush Rat.

The Agile Antechinus usually nests in tree hollows (Menkhorst and Knight 2011). Fortunately numerous old growth trees with suitable nest sites survived the 2014 fire, no doubt providing refuges for this common marsupial. The old growth trees that survived the fire also provided refuges for the two arboreal marsupials, Eastern Ringtail Possum and Sugar Glider, that were recorded both pre- and post-fire. Studies in the Central Highlands of Victoria, in River Red Gum *Eucalyptus camaldulensis* habitat in western Victoria and in the Nadgee Nature Reserve have shown that arboreal marsupials are able to survive even the most severe wildfire, provided that suitable areas of canopy remain unburnt, especially in wet areas, along gullies and watercourses (Newsome *et al.* 1975; Homan 2012; Berry *et al.* 2015). The chance sighting of a Koala emerging from within the adjoining coal mine in February 2018 was unexpected (Fig. 4). This was the first confirmed, available record for this species in the Morwell district for 40 years (Victorian Biodiversity Atlas). Koalas have not been recorded in any of the other YMCMP off-set blocks since intensive surveys began in 2007.

Wildfire has the potential to significantly alter vegetation and habitat structure. Several years post-fire, a dense regrowth of tall shrubs and eucalypt saplings, amongst a tangle of fallen

Fig. 4. Koala emerging from Yallourn coal mine. Photo courtesy of Energy Australia.

trees and branches is often produced (Homan 2012). This process occurred throughout Block 5 (Fig. 5), whereas pre-fire this area of Plains Grassy Forest was much more open. This change in habitat suited the Swamp Wallaby, which was recorded in large numbers post-fire. Similar results have been found for this species in other studies, especially two to five years post-wildfire (Lunney and O'Connell 1988; Homan 2012).

Severe bushfires initially kill many individual animals; however, the pre- and post-fire surveys in YMCMP Blocks 4 and 5 confirm that both terrestrial and arboreal native mammal communities are able to survive wildfire in small, isolated blocks provided that suitable habitat refuges remain unburnt. These surveys also highlight the importance of small areas of native vegetation and habitat in highly fragmented and disturbed landscapes.

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Fig. 5. Eucalypt regrowth, Block 5, October 2018.

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Short-beaked Echidna, caught by surveillance camera.

Observations from a trial spool-and-line tracking study

Background

In 2009, a capture-mark-recapture trapping study commenced at New Chums Road in the Brindabella Ranges of the Australian Capital Territory to investigate the impact of the 2003 bushfires on small mammals (see Fig. 1b, Davies and Drew 2014, for trapping arrangement). Live trapping was conducted along a 1200 m section of a narrow forest road over a three-year period, with traps set in pairs, one on either side in the roadside vegetation. Traps were also set in a small creek gully which crossed under the road via a concrete pipe. Three species of native small mammals were captured: Bush Rat *Rattus fuscipes*, Agile Antechinus *Antechinus agilis* and Dusky Antechinus *A. swainsonii*. All captured animals were individually identified using pet microchip tags (Allflex™ Passive Integrated Transponder or PIT tags). Despite high numbers of captures overall, and many recaptures of animals on the same side of the road, no individual animal was recaptured on the opposite side of the road from previous captures except in the gully. This suggested that the road was acting as a barrier to small mammal movement except where the gully pipe may have been providing safe passage. Evidence for roads acting as at least partial barriers to movement for some small mammal species has been presented by several studies (Bond and Jones 2008; Burnett 1992; Clark *et al.* 2001; Clevenger *et al.* 2001; Goosem 2001). To test this theory, the project was expanded to include a pilot study trial of the spool-and-line tracking method.

Spooling trial

The spool-and-line tracking technique involves attaching a small white nylon bobbin to the back of the animal, normally using a small amount of super glue. The start of the thread is tied to vegetation at the point of release and it then unravels from the core of the bobbin as the animal moves away. By this method, the exact path taken by the animal can be followed (e.g. Strauss *et al.* 2008). Spool attachment is normally done at night as most movements are nocturnal, then the thread is followed the next day. The lightest possible spools are used, to ensure the animal is carrying no more than 10% of its body weight. The spools used were of two sizes, here described as 'A' and 'B'. The 'A' spools were Danfield™ 72-10S Precision Bobbins. They measured 40 mm long × 15 mm at widest point (average 3.95 g, range 3.9–4.0 g, n=10) and contained approximately 246 m of thread. The 'B' spools were Windsor™ WIN-BOB-140/2 Size 8 bobbins. They measured 35 mm long × 12 mm at the widest point and weighed 2.5 g each (n=10) and contained approximately 154 metres of thread. Each spool was covered with brown heat shrink to protect the spool, to provide a glueing surface so the thread was not glued to the fur, and to provide some camouflage for the white thread. Each piece of heat shrink averaged 1 g in weight (range 1.0–1.1 g, n=10).

Previous research (Davies and Drew 2014) showed adult male Bush Rat body weights averaged 139 g (range 130–160 g) and adult female Bush Rats averaged 125 g (range 110–152 g). Adult male Dusky Antechinus averaged 62 g (range 47–78 g) and adult females averaged 53 g. Adult male Agile Antechinus averaged 22 g (range 17–29 g) and adult females averaged 21 g (range 21–23 g). Hence, an 'A' spool weighing 4.95 g (spool plus heat shrink) on an adult male Bush Rat would be 3.6% of body weight and on an adult female Bush Rat 3.9%. A 'B' spool on an adult male Dusky Antechinus would be 5.6% and on an adult female 6.6%. An 'A' spool on an adult male Agile Antechinus would have been 22.5% and a 'B' spool would be 15.9%, clearly too heavy. To bring spool weights below 10% of Agile Antechinus body weight, we manually removed thread from each bobbin until the desired weight limit for an average Agile Antechinus was achieved. For a 21 g animal this meant a combined total weight (spool plus heat shrink) of 2.1 g. This process left the spool containing 86 m of thread.

We proposed to use two animals of each of the three species in our trial. In October 2010, we captured two Bush Rats (Spools 1 and 2) and in April 2011 we captured two Agile Antechinus (Spools 3 and 4) and followed their threads the day after capture. Movement distances presented are estimates based on pacing along the thread path. No Dusky Antechinus were captured during the trial.

Trapping arrangements and movement paths for October 2010 and April 2011 are presented in Fig. 1. In October 2010, Spool 1 was carried by an adult male Bush Rat (134 g) captured in the gully (trap G10). It moved up the slope out of the gully where the thread was found snapped after approximately 100 m. Spool 2 was carried by another adult male Bush Rat (145 g) that was also captured in the gully (trap G1). It moved up and out of the gully and over a ridge, travelling approximately 150 metres where it entered a burrow and did not re-emerge. The thread showed both rats moved under, in and on top of fallen logs. In April 2011, Spool 3 was carried by an adult male Agile Antechinus (29 g) captured in the roadside vegetation (trap 12a). It was released 5 m away from the road. It travelled approximately 45 m before the thread was found snapped. The animal made apparently normal movements including tree climbing and along fallen logs. Spool 4 was carried by an adult female Agile Antechinus (25 g) caught in the roadside vegetation (trap 15a). It was released 5 metres from the roadside. The entire spool, including heat shrink wrapping, was recovered after only 1 m in heavy forest litter.

This small-scale trial demonstrated a successful deployment of the spool-and-line tracking technique on two species of small mammals where 3 out of 4 spools gathered valuable information. The unsuccessful deployment likely suffered from insufficient application of glue. Dusky Antechinus were present at lower abundances during the study so it is no surprise they were not captured during the trial. However, considering the smaller Agile Antechinus carried a spool for 45 m and appeared to move normally, we are confident this technique will work for Dusky Antechinus too. No road-

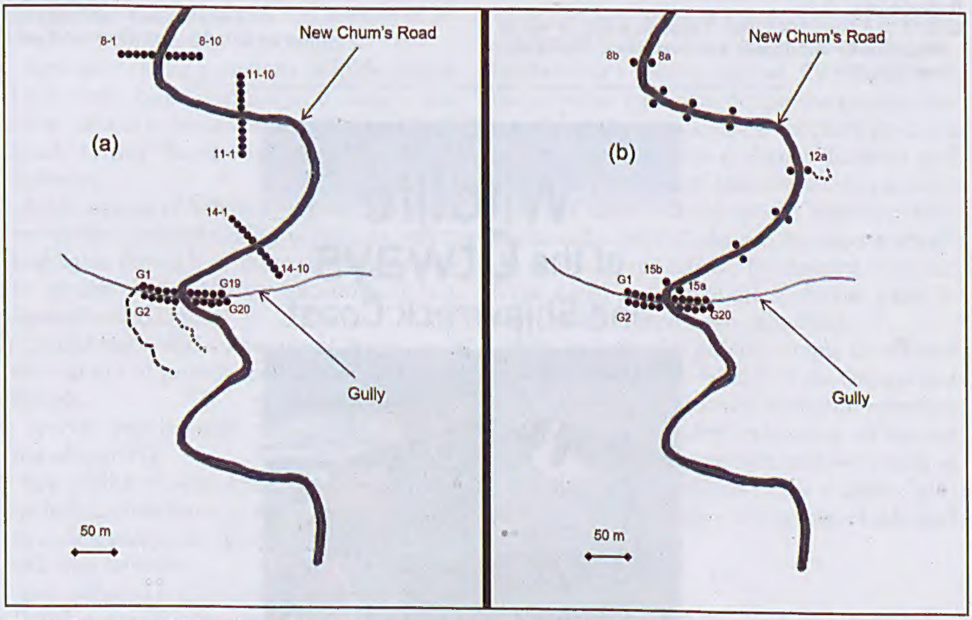

Fig. 1. Diagram of New Chums Road showing traps (large black dots) in October 2010 (a) and April 2011 (b) modified from Fig. 1 in Davies and Drew (2014). Movement paths for October 2010 are long dash (Spool 1) and short dash (Spool 2) and short dash for April 2011 (Spool 3). Spool 4 not shown on diagram. Gully traps are numbered G1 to G20. Roadside prefix trap numbers relate to numbering protocol from another study (Drew *et al.* 2015), suffix numbers denote traps 1–10 and 'a' and 'b' refer to one side of the road or the other.

crossing event was revealed by spooling, either across the road surface or via the under-road pipe, but sample sizes were very low. In October 2010 and in April 2011, a small amount of water flowed in the creek through the pipe but it is unlikely this water proved a deterrent to animals.

We intend to use the results from this small pilot study to inform the design of a larger-scale experimental research project to further explore whether roads act as barriers to small mammal movements and whether they use culverts to overcome these barriers.

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Wildlife of the Otways and Shipwreck Coast

by Grant Palmer

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The Otways and Shipwreck Coast, extending from Torquay in the east to Warrnambool in the west, and from the coast to Colac in the north, is a region that is as diverse as it is beautiful. Habitats range from coastal heath to cool temperate rainforest, supporting rich and diverse wildlife communities. *Wildlife of the Otways and Shipwreck Coast* is a beautifully illustrated and comprehensive guide to the region's vertebrate wildlife, providing a photographic key to the region's species, a description of habitats, as well as a general background to the history and significance of the region as a 'Key Biodiversity Area'.

The book comprises an Introduction (guidelines on how to use the book and sources of information), followed by five chapters:

1. Summary of the vertebrate wildlife groups (mammals, birds, reptiles and frogs), and three distinct invertebrates: Otway Black Snail, Otway Burrowing Crayfish, Otway Stonefly;
2. A description of habitat types, and the commonly encountered wildlife species, as well as highlights for each of these. Highlights may be species that are rarely encountered (e.g. Spotted-tailed Quoll);
3. Conservation and management, including a description of protected areas as well as key threats;
4. Species' profiles (288 native and 21 introduced species);
5. Key wildlife viewing locations (14 locations) including directions, a description of facilities, suggestions on what to do, and wildlife that may be seen.

Also included is a list of incidental records of wildlife species that have been recorded but not considered representative of the region, and a checklist to enable the book's user to keep track of species seen.

Most of the book is dedicated to the profiles of 288 native species of birds, mammals, frogs and reptiles that occur in terrestrial environments and coastal waters of the region. Species described include those that may be locally extinct (e.g. Smoky Mouse, last recorded in 1930), rare (e.g. Spotted-tailed Quoll), seasonal migrants (e.g. Tree Martin), and those that are common (e.g. Grass Skink). Each profile fills half a page and includes a photo, identifying characteristics of the species, range and conservation status, habitats, ecology and a distribution map. Profiles for introduced species include only a photo and a brief description of the species.

Distribution maps of species do not provide much detail of locations but are useful for understanding a species' general distribution and the potential for encountering the species. The maps show locations where species have been recorded in the *Atlas of Living Australia* and *Victorian Biodiversity Atlas*. Based on a combination of these records, species' habitat preferences, and expert elicitation, the areas in which the species 'could reliably be expected to occur' (core areas) and where the species is 'particularly common' have been delineated.

With its beautiful photos, simple layout and uncomplicated text, *Wildlife of the Otways and Shipwreck Coast* provides a useful reference for visitors and residents who have an interest in wildlife and conservation, and who wish to gain a better appreciation of the wildlife, habitats and natural history of this remarkable part of Victoria.

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